THE SEX-COMPOSITION OF HUMAN FAMILIES

By JOHN BENJAMIN NICHOLS

It is the purpose of this paper to present the results of a study of the sex-composition, that is, the number of sons and daughters, respectively, of 3,000 human families of six or more children each.

The data for this study were obtained from the genealogical records presented in the *History of Hingham, Massachusetts*, published by the town; in S. Judd's *History of Hadley, Massachusetts;* in D. M. Hoyt's *Old Families of Salisbury and Amesbury, Massachusetts;* in J. O. Austin's *Genealogical Dictionary of Rhode Island;* in W. W. Ingraham's *History of the Castle Family;* from manuscript genealogical and other data in my possession; and a few data (enough to complete the 3,000 familes) from James Savage's *Genealogical Dictionary of First Settlers of New England.*

In order to avoid the disturbing numerical influences in small families, the study was confined to large families, of six or more children each. Only those families derived from a single pair of parents are included in the enumerations: for instance, if a man were married more than once and had six (or more) children by one wife and fewer than six by another wife, the six born to the one couple were counted in as a complete family, and the others were disregarded. In a few instances where a man or a woman had more than five children by each of two wives or husbands, the two sets of children were taken as two separate families. Each family in this series therefore represents the progeny of the same father and mother. The families were taken as they came, without any selection whatever.

The vast majority of the families enumerated — probably more than 95 per cent. — were of Anglo-Saxon race and located in New England. An insignificant proportion were of Irish, Scotch, or other origin; no colored families were knowingly included. The period of time embraced by these families covers more than three hundred years, from the year 1600 (and even earlier) to the present

time. A large majority of the families enumerated date between the years 1640 and 1800.

For the purposes of a study of this kind the sex of premature and stillborn infants is of as much importance as that of those born living; family records are, however, inevitably incomplete in this respect, and the unrecorded stillborn children must be ignored in the enumeration. In a few instances children whose sex was not recorded or not determinable from their first names were omitted from the count. The possibility of some — probably only a small proportion — of the family records being incomplete must also be admitted. Late marriages, or the death of either parent during the mother's childbearing period, also cause possible abbreviation of potential families. The necessary omission of occasional missing, unrecorded, or indeterminate individuals from this enumeration can not materially affect the general results, since the numbers of males and females thus omitted will in the long run very nearly balance each other.

The material here utilized, in spite of its partial antiquity, is probably as reliable for its purpose as can be practicably obtained or demanded. The data required in this study were sought mainly from records of a century or two back, first, because in those days the large families here contemplated were more numerous than now; and, second, because family records for that period are more accessible, more abundant, and quite as accurate as the records of the present time.

With these remarks on the source and character of the data, the actual results of the enumeration of the number of males and females in each of the 3,000 families are presented in Table I. In this table the first three columns show the different numerical combinations of the two sexes making up the various families, while the fourth column gives the total number of families of each combination enumerated. Thus, there were 11 families consisting of 6 sons and 0 daughters, 71 of 5 sons and 1 daughter, 154 of 4 sons and 2 daughters, etc.

In all, 3,000 families were enumerated, embracing 12,935 males and 11,941 females, or a total of 24,876 individuals. The average number of members in each family was 8.3, — 4.3 sons and 4.0

daughters. The proportion of males to females was as 108.3 to 100. This proportion of males is somewhat higher than the usual general ratio at birth, which is ordinarily in the neighborhood of 105 or 106; thus, in 59,350,000 births in Europe there was a ratio of 106.3 boys to 100 girls; and of 2,063,386 births in the United

TABLE I. *Statistics of Sex-composition of 3,000 Families*

Number in Family.			Number of Families.	Probable Number of Families.	Number in Family.			Number of Families.	Probable Number of Families.	Number in Family.			Number of Families.	Probable Number of Families.	Number in Family.			Number of Families.	Probable Number of Families.
Males.	Females.	Total.			Males.	Females.	Total.			Males.	Females.	Total.			Males.	Females.	Total.		
6	0	6	11	12	9	0	9	1	1	4	7	11	25	29	10	4	14	3	
5	1	6	71	66	8	1	9	12	10	3	8	11	10	14	9	5	14	2	
4	2	6	154	152	7	2	9	37	38	2	9	11	9	4	8	6	14	4	
3	3	6	186	188	6	3	9	79	82	1	10	11	0	1	7	7	14	1	
2	4	6	128	130	5	4	9	118	114				207	207	6	8	14	5	
1	5	6	45	48	4	5	9	94	105						5	9	14	4	
0	6	6	8	7	3	6	9	73	65	11	1	12	0	1	4	10	14	1	
			603	603	2	7	9	23	26	10	2	12	2	3	3	11	14	1	
					1	8	9	11	6	9	3	12	11	8				21	
7	0	7	5	7	0	9	9	0	1	8	4	12	17	17					
6	1	7	43	42				448	448	7	5	12	23	25	10	5	15	2	
5	2	7	119	118						6	6	12	31	27	9	6	15	2	
4	3	7	200	181	9	1	10	5	5	5	7	12	22	22	8	7	15	3	
3	4	7	161	168	8	2	10	27	19	4	8	12	8	12	7	8	15	1	
2	5	7	78	93	7	3	10	40	47	3	9	12	5	5	6	9	15	1	
1	6	7	31	29	6	4	10	81	75	2	10	12	2	1	5	10	15	1	
0	7	7	5	4	5	5	10	69	84										
			642	642	4	6	10	71	65				121	121				10	
					3	7	10	34	34	13	0	13	1	0	11	5	16	1	
8	0	8	3	3	2	8	10	13	12	11	2	13	0	1	8	8	16	2	
7	1	8	24	22	1	9	10	3	2	10	3	13	3	2					
6	2	8	70	70				343	343	9	4	13	4	5				3	
5	3	8	114	130						8	5	13	4	8	10	8	18	1	
4	4	8	154	150	10	1	11	1	2	7	6	13	9	10					
3	5	8	128	111	9	2	11	2	7	6	7	13	12	9	11	9	20	1	
2	6	8	45	51	8	3	11	30	20	5	8	13	6	6					
1	7	8	13	14	7	4	11	41	37	4	9	13	3	3	5	16	21	1	
0	8	8	2	2	6	5	11	43	48	3	10	13	2	1					
			553	553	5	6	11	46	45	2	11	13	2	1					
													46	46					

States during the census year 1900 there were 104.9 males to every 100 females. The figures of Janse and of Geissler[1] both show that in large families the proportion of sons at birth is greater than in small families, and the high rate of sons found in my series is probably due, in part at least, to the fact that this series is based on large families.

[1] See references at the close of the article.

In looking over the relative numbers of sons and daughters making up the various families, we find all gradations from those families in which the sexes are evenly divided to unisexual families in which the children are entirely of the same sex, all sons or all daughters.

By applying the theory of probabilities to the observed sex-composition of large numbers of families, an interesting and important relation is brought out.

To illustrate the method of elaborating and applying this theory, suppose (what is not quite true) that the general chances of any child being born a boy or a girl are equal. Then the chances of the first child being, say, a boy are 1 : 2; the chances of the second child being a boy are also 1 : 2, but the chances of both being sons are $\frac{1}{2} \times \frac{1}{2}$, or 1 : 4. Similarly, in a family of 6, the chances of all being sons is $1 : 2^6$, or 1 in 64. In families of 6 children, there are 64 possible arrangements or permutations or order of birth of sons and daughters, any one of which would be as likely to occur as any other; or the chance of each would be 1 : 64. Of these permutations there are six presenting the combination of 5 sons and 1 daughter, according as the daughter is the first, second, third, fourth, fifth, or sixth child; and the chances that a family of six would consist of 5 sons and 1 daughter would be 6 in 64. By applying this method of calculation, out of every 64 families of 6 children each the general probabilities (regarding the two sexes as having equal chances) are that there would be

1	family	of	6	sons	and	0	daughters
6	families	of	5	"	"	1	"
15	"	"	4	"	"	2	"
20	"	"	3	"	"	3	"
15	"	"	2	"	"	4	"
6	"	"	1	"	"	5	"
1	"	"	0	"	"	6	"
64	"	"	6 children each.				

The chances that a child born will be a son or a daughter are, however, not quite equal, but are slightly in favor of the male sex. The general average ratio of the sexes in the families here enumerated being about 108 : 100, for the purposes of this study the

chances of a child being a son are taken as 108 : 208, and of being a daughter as 100 : 208. Each permutation of m sons and n daughters would, then, have a chance of occurring $108^m \times 100^n$ times in 208^{m+n} families. This ratio makes the calculations more cumbersome, but gives a more accurate result. In Table I, along with the number of families of each combination as actually observed is given, in the fifth column, the number called for by the theory of probabilities, calculated on the basis of 108 : 100. Thus, out of 603 families of 6 children, 11 consisting entirely of sons actually occurred, while the theory of chances called for 12; 186 families actually consisted of 3 sons and 3 daughters, while the probable number was 188; and so on.

It will be immediately seen on examination of Table I that there is throughout a very close correspondence between the number of families actually observed and the number called for by the theory of probabilities. In other words, the sex-composition of families practically agrees with the laws of chance.

After completing this enumeration and arriving at the results stated, I found on searching the literature two and only two other studies of the same subject, those of Janse and of Geissler.

Janse gives statistics of 2,412 families of Middelburg, Holland, of 1 to 16 children each, aggregating 8,818 children. He gives (pages 125–142) the numbers of families not only of each combination of sexes but also of each permutation or order of birth of sons and daughters; he does not, however, apply the theory of probabilities to the subject.

Geissler, having at his command the unexampled facilities and data of the vital registry bureau of Saxony, has presented an analysis of the statistics of no fewer than 4,794,304 children, of 998,761 families, born in Saxony, 1876–1885. In a careful comparison of the various sex-combinations in his families of 2 to 12 children each he found an extremely exact correspondence of the actual numbers with the numbers called for by the theory of probabilities, except that in the case of families entirely of the same sex the actual numbers slightly exceeded the probable. He also gives an exhaustive study of the actuality and probability of the sex of children born after given sex-combinations already exist, and concludes that in general there is a tendency toward the equalization of the number

of the two sexes in each family; excepting, again, that in a small proportion of cases there appears to be a definite tendency to the generation of children all of the same sex.

Large unisexual families always attract attention, and nearly every one has noted instances within his own knowledge of large families consisting entirely or mainly of sons or of daughters. My series includes a family of 13 children all of whom were sons. Rauber (page 79) cites a family of 14 girls, born to a single pair of parents; and Geissler's statistics include one family of 14 sons and another of 16 daughters. Although such families are conspicuous, the tendency to the generation of large unisexual families is no greater, according to my statistics, or only slightly greater, according to Geissler's hundredfold more extensive statistics, than the theory of probabilities calls for.

It may be accepted as fairly demonstrated that the actual sex-composition of human families practically corresponds with that called for by the theory of chance. Is this correspondence to be taken as an indication that the determination of sex and the sex-composition of families are entirely fortuitous? Or is it not rather consistent with the view that real forces are at work in the parents or germ cells governing sex determination, such that the correspondence noted is simply the arithmetical expression of the varying strengths of these sex-determining forces in different families yielding the general average ratio of 108 : 100 (or whatever the exact ratio at conception is) as representing the relative strength of the forces tending to produce males and females respectively?

If terms would be useful in this connection to denote the tendency in parents to produce male or female children, the following might be employed:

Arrhenogenic, = male-producing, or the tendency in a parent (either father or mother) to produce male children; from ἄῤῥην, male, ἀῤῥενόγονος, producing male children.

Thelygenic, = female-producing, the tendency in a parent to produce female children; from θῆλυς, female, θηλυγόνος, producing female children.

Rauber uses the terms *Arrhenotokie*, *Thelytokie*, etc., (τόκος, childbirth).

Supposing that every parent has a special power toward the

determination of the sex of his or her offspring, the sex-composition of any family born to a single pair of parents would be the resultant from the fusion of the sex-determining powers of the two parents. Opposite sex-determining influences in the two parents would tend to neutralize each other, while similar influences would be strengthened. With a single pair of parents it is not possible to form a judgment as to the special sex-determining power, arrhenogenic or thelygenic, of either parent. A study of families resulting from multiple marriages, in which one parent was married more than once, might reveal a constant sex-determining influence on the part of the parent multiply married that would be manifest in the offspring by different consorts. It is not often that a father has six or more children by each of two wives, so that in this study there are too few families of this sort from which to draw any satisfactory conclusions. The data obtained, so far as they go, are as follows: Fourteen fathers who had more than five children by each of two wives, and each of whom by the first marriage had more sons than daughters, had by the first marriages a total of 79 sons and 34 daughters, and by the second marriages 66 sons and 42 daughters; if in this series the predominance of sons in the first marriages can be interpreted as due to a dominant arrhenogenic power in the fathers, then the same dominant tendency to the generation of males is in general observable in the second marriages. On the contrary, 7 fathers, each of whom by his first marriage had more daughters than sons, had by the first marriages 16 sons and 37 daughters, and by the second marriages 33 sons and 29 daughters; the dominant thelygenic tendency in the first unions in this series was not maintained in the second unions. These data are insufficient for generalization; but a study of larger series, embracing mothers as well as fathers and not limited to large families, might yield some reliable conclusions as to the possession of special sex-determining powers by individuals.

If there is any special sex-determining influence, in either an arrhenogenic or thelygenic direction, inherent in individuals, and this tendency is transmissible to the offspring, then a study of the different families or generations descended from the same common ancestors might reveal traces of the existence of such tendency.

Table II gives the aggregate sex-composition of numbers of families (of more than five children each) descended in the male line from common ancestors.

TABLE II. *Aggregate Sex-composition of New England Families (of 6 or more Children each) Descended in Male Line from Common Ancestors.*

Name of Common Ancestor.	Number of Families.	Total Number of Sons.	Total Number of Daughters.	Total Number of Children.	Number of Sons for 100 Daughters.
Leavitt, John.	11	55	31	86	177
Barnes, Thomas	11	64	38	102	168
Cushing, Matthew	47	259	169	428	153
Humphrey, Thomas	13	59	42	101	140
Loring, Thomas	26	119	89	208	134
Smith, Joseph	18	81	65	146	125
Nash, Timothy	18	82	66	148	124
Dickinson, Nathaniel	49	218	177	395	123
Hobart, Edmund	28	131	108	239	121
Sprague, William	27	119	100	219	119
Thaxter, Thomas	15	71	60	131	119
Stodder, John	43	210	180	390	117
Lincoln, Thomas[1]	8	34	29	63	117
Burr, Simon	14	64	56	120	114
Smith, Samuel	57	261	229	490	114
Bates, Clement	24	194	92	196	113
Lane, William	17	67	60	127	111
Gardner, John	25	111	100	211	111
Nichols, Thomas	16	75	68	143	110
Tower, John	22	103	96	199	107
Warner, Andrew	11	50	47	97	106
Kellogg, Joseph	23	101	96	197	105
Hastings, Thomas	10	49	47	96	104
Fearing, John	17	67	66	133	102
Lincoln, Stephen[1]	17	67	67	134	100
Dunbar, Robert	16	68	69	137	99
Hersey, William	36	142	143	285	99
Lincoln, Thomas	18	77	78	155	99
Stowell, Samuel	13	52	54	106	96
Montague, Richard	13	53	56	109	95
Whiton, James	42	161	174	335	93
Porter, Samuel	14	57	61	118	93
White, John	22	83	89	172	93
Jones, Robert	10	39	42	81	93
Lincoln, Samuel	28	111	123	234	90
Lewis, George	11	44	49	93	90
Lincoln, Daniel	11	41	48	89	85
Beal, John	37	145	174	319	83
Jacob, Nicholas	11	35	48	83	73
Wilder, Edward	29	109	152	261	72
Total	878	3838	3538	7376	108.5

The first item of this table shows, for instance, that in 11 families descended in male line from John Leavitt there were in all 55

[1] Brothers.

sons and 31 daughters, a ratio of 177 sons to 100 daughters; and so with the others. The total number of families enumerated is 878, with a total of 7,376 individuals, and an average ratio of 108.5 males to 100 females, practically the same ratio as in my entire series of 3,000 families. The different families are arranged in the order of the ratios of sons to daughters, and range from the Leavitt families, averaging 177 sons, to the Wilder families, averaging only 72 sons, to every 100 daughters. These statistics are perhaps too limited to warrant any very positive conclusions; but they serve as a contribution to the subject, and in some of the cases, as the 47 Cushing families with a ratio of 153 sons, or the 37 Beal families with a ratio of 83 sons, the number of families appears sufficiently large and the departure from the average ratio of the sexes sufficiently marked to eliminate chance and show that in some individuals and families there is a hereditary tendency to the production of sons, and in others of daughters. This table necessarily presents the influence of only one line, the male; the female lines coming in at each marriage of course affect the sex-determining tendency, but both parental influences can not be exhibited in this method of presentation, and a markedly predominant tendency to produce all children of one sex even if on one side only ought to be brought out by this method. On the whole, the data exhibited in Table II would seem to show that in different families there are marked hereditary differences in the sex-determining tendencies. Other observers (von Lenhossék, Lorenz) also have expressed a belief that in some families there are hereditary tendencies to a predominance of sons, in others of daughters.

If there is a special parental sex-determining power shown by the data in Table II, it is exerted, be it noted, on the male or paternal side; and, contrary to recent theories that sex is determined exclusively through the mother, indicates that in the case of man at least the paternal side has some sex-determining influence.

If there is a hereditable sex-determining power, it would be natural to expect that the members of large unisexual families, in which the children are all or nearly all of the same sex, would themselves show a marked tendency to produce children predominantly of that sex. This, however, is often not the case.

Thus, in one case, a couple had 9 sons and 1 daughter; eight of these sons had an aggregate of 34 boys and 30 girls (one of them having 5 sons and 0 daughters, another 2 sons and 8 daughters); so that although in the first generation males overwhelmingly predominated, in the second generation the two sexes were nearly evenly divided. In a second case, of a family of 8 sons and 1 daughter, four of the sons had 18 boys and 16 girls. In a third case, out of a family of 2 sons and 10 daughters, eleven had 39 boys and 35 girls. In a fourth case, out of a family of 1 son and 8 daughters, five of the daughters had 13 boys and 11 girls, while the son had 6 boys and 1 girl; total, 19 boys and 12 girls.

One remarkable case to the contrary, however, is included in my data. A couple still living in Essex, England, had a family of 13 children, all sons; to the present time, five of these sons have had children, aggregating 10 boys and only 1 girl. This case is perhaps to be regarded as one in which a powerful arrhenogenic influence in the parents was transmitted to the sons.

Geissler's finding that in a small proportion of families there appears to be a definite tendency to the generation of children all of the same sex, over and above what the laws of probability would call for, would point to the existence of positive sex-determining powers in parents.

In view of the foregoing considerations, we might speculate on the question as to the apparent operation of pure chance in the determination of sex and the sex-composition of families in this way: Two opposite sex-determining powers are resident in parents, one arrhenogenic or male-producing, the other thelygenic or female-producing. These two powers occur in individuals in definite absolute and relative strengths, capable, were the fundamental cellular forces completely known, of being quantitatively expressed; and they vary widely in strength in different individuals, from strong arrhenogenesis to strong thelygenesis. Each pair of parents possesses a definite net sex-determining power or coefficient, the resultant of the combined sex-determining powers of the two individual parents; and the number of sons and daughters generated may be taken as a result, and as a quantitative expression or measurement

of the comparative strengths of these two forces in the parents. For instance, suppose one parent to have a net arrhenogenic power twice the strength of a net thelygenic power in the other parent; then the net resultant sex-determining power in the pair would be such that there would be a tendency to produce two sons for every daughter. For the race at large the general average relative strengths of the arrhenogenic and thelygenic forces are at conception approximately in the ratio of 115 : 100 (Rauber), or 111 : 100 (von Lenhossék), respectively, which after allowing for the excessive intrauterine mortality of male fetuses yields the ratio at birth of from 105–108 boys to 100 girls. The net sex-determining powers or coefficients vary through a wide range in different pairs of parents, and, considering that in each pair they result from the fortuitous union of individuals with differing or unknown coefficients, these varying powers are probably distributed among the parental pairs in such a way quantitatively as to agree with the numerical expression of the theory of chances. According to this hypothesis, then, the sex-composition of families agrees with the laws of chance, not because the determination of sex is a pure matter of chance, but because the cellular forces that govern the determination of sex and tend to produce males and females respectively are distributed among the various pairs of parents in arithmetical agreement with the theory of probability.

In a comparatively small number of families included in my enumeration (771) the sex of the firstborn child was noted. Similar statistics have been collected and presented by Geissler and by Orschansky. The three series of data are shown in Table III.

These three series of data agree with one another in showing that there is a general agreement between the sex of the first child and the sex of the majority of the children in families; in families beginning with a son there is in general an excess of male over female children, and vice versa. After deducting the firstborn children, however, the remaining children of the families present, as shown by the last column of the table, the usual proportions between the sexes. The general agreement between the sex of the first child and the sex of the majority of the children, therefore, is a purely arithmetical result of the method of classification employed, and

arises from the numerical advantage to each sex resulting from arranging the families according to the actual sex of the first child. A similar agreement would doubtless be found if the families were classified by the sex of the second, third, last, or any child. Aside from this accidental correspondence, the idea that the sex of the first child in any potential sense dominates or characterizes the sexual type of the family does not seem warranted.

TABLE III. *Statistics of Sex of Firstborn*

	Number of Families.	Number of Sons.	Number of Daughters.	Number of Sons for each 100 Daughters.	
				Including Firstborn.	Excluding Firstborn.
Geissler :					
Families in which firstborn was male....	5,143	22,484	16,518	136	105
Families in which firstborn was female..	5,000	16,797	21,232	79	103
	10,143	39,281	37,750	104	
Orschansky :					
Families in which firstborn was male....	1,246	3,907	2,768	141	96
Families in which firstborn was female..	1,196	2,768	3,831	72	105
	2,442	6,675	6,599	101	
Nichols :					
Families in which firstborn was male....	415	2,042	1,456	140	112
Families in which firstborn was female..	356	1,367	1,658	82	105
	771	3,409	3,114	109	
Aggregate :					
Families in which firstborn was male....	6,804	28,433	20,742	137	104
Families in which firstborn was female..	6,552	20,932	26,721	78	104
Total.....	13,356	49,365	47,463	104	

In the 13,356 families embraced in the aggregate of the foregoing series the ratio of the families in which the firstborn was male to those in which the firstborn was female is as 103.8 to 100, practically the same as the general ratio of the sexes (104 : 100) in the entire number of individuals belonging to these families.

Summary: In this study, covering 3,000 families of six or more children each, aggregating 24,876 individuals, the average ratio of the sexes born was 108.3 males to 100 females. In the

sex-composition of the various families all gradations were found from those exclusively or preponderatingly male, through those in which the sexes were mixed in various proportions, to families preponderatingly or exclusively female. It was found that the actually observed numbers of families of each sex-combination correspond very closely with the numbers required by the theories of probabilities, calculating on the basis that the general chances that any given child would be a male would be as 108 in 208. This correspondence, however, was not taken as necessarily indicating that the determination of sex in families is entirely a fortuitous matter, rather than under the government of forces resident in the parents or germ cells; although these sex-determining forces might be distributed in varying strength among the various parents in quantitative agreement with the laws of chance. A compilation of numerous families in various generations descended from common ancestors seemed to show that parents may possess definite and specific sex-determining powers that are transmissible to offspring, and vary in different individuals and different families. As in this compilation the lines of descent were shown on the male side only, it would seem that in the case of man at least the father has some influence in the determination of the sex of his offspring. It was also shown that in general the sex of the firstborn child agrees with the sex of the majority of the children in families, but simply as an arithmetical result from the numerical advantage arising from arrangement of the families according to the sex of the first child.

References

JANSE, L. *Bijdrage tot het onderzoek naar de oorzaken der geslachtsverhouding bij de geboorten.* Middelburg, 1853. Pp. 171.

GEISSLER, ARTHUR. *Beiträge zur Frage des Geschlechtsverhältnisses der Geborenen. Zeitschrift des k. sächsischen statistischen Bureaus,* Dresden, 1889, XXXV, pages 1–24 and 56.

RAUBER, A. *Die Ueberschuss an Knabengeburten und seine biologische Bedeutung.* Leipzig, 1900. Pp. 220.

ORSCHANSKY, J. *Die Vererbung im gesunden und krankhaften Zustande und die Entstehung des Geschlechts beim Menschen.* Stuttgart, 1903. Pp. 347.

VON LENHOSSÉK, M. *Das Problem der geschlechtsbestimmenden Ursachen.* Jena, 1903. Pp. 99.